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This DURIP grant provided the instrumentation needed for measuring the flow structure and turbulence in axial turbomachines. The main components are: i. A dual head, injection seeded, 300 mi/pulse, Nd YAG laser; ii. The optical components for assembling two dimensional Particle Image Velocimetry (PIV) and three dimensional holographic PIV systems; iii. The components for a dedicated holographic PIV reconstruction system, including the optics and image acquisition systems. These instruments are integral ports of our effort to develop a laboratory for measuring the flow structure within axial turbomachines and to use the data for addressing a series of turbulence modeling issues.

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Instrumentation for 2D and 3D PIV In Axial Turbomachines

AFOSR GRANT No. F49620 – 97 – 1 – 0136 E83-2133

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Progress Report

This DURIP grant provided the instrumentation needed for measuring the flow structure and turbulence in axial turbomachines. The main components are: i. A dual head, injection seeded, 300 mj/pulse, Nd YAG laser; ii. The optical components for assembling two dimensional Particle Image Velocimetry (PIV) and three dimensional holographic PIV systems; iii. The components for a dedicated holographic PIV reconstruction system, including the optics and image acquisition systems. These instruments are integral parts of our effort to develop a laboratory for measuring the flow structure within axial turbomachines and to use the data for addressing a series of turbulence modeling issues.

The axial turbomachine test facility has been designed and constructed to allow detailed measurements of the velocity distribution within an entire stage including the rotor, stator, gap between them, inflow into the rotor and the wake structure downstream of the stator. Substantial part of the support for assembling this facility has been provided by another AFOSR grant (as well as from ONR) which is closely integrated with this project. The equipment mentioned above has been purchased specifically for use in this facility. This setup provides a realistic representation for flow conditions in multi-stage axial turbomachines (excluding compressibility effects) including realistic blade geometries, high Reynolds numbers and closely spaced blades that characterize aircraft compressors. It also provides unobstructed view for 2-D PIV and 3–D holographic PIV measurements within the entire stage, including the boundary layers on the blades, the flow around the hub and the tip leakage region.

While the axial facility is being constructed (it is nearing completion), we purchased all the instrumentation included in the present DURIP proposal. The dual head Nd-Yag laser has been purchased and integrated into our laboratory PIV systems. It has been used extensively for PIV measurements of high Reynolds number flows in jets and within an existing centrifugal pump test facility that has a vaned diffuser. The flow in this facility also involves rotor-stator interactions and the modeling problems are quite similar to flows in axial turbomachines. The data has already been used for developing the analysis and modeling tools that will be used in the axial facility.

Using the funds provided in the present grant we have also purchased the components, assembled and integrated a new holographic reconstruction system for analysis of HPIV data. This system consists of the optics for illuminating the holograms, the video camera with a microscope objective for scanning the reconstructed three dimensional field, the 3-D, computer

controlled, precision translation stage for controlling the location of the camera within the reconstructed field. We have also purchased a host computer, an image frame grabber that digitizes the images acquired by the video, and the software for processing the data. The same computer also controls the precision translation stage. This reconstruction and scanning system is now fully operational and is already being used for analysis of holograms as well as for the development of advanced algorithms for data processing.